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Observation of whale shark, *Rhincodon typus* (Smith, 1828) off Goa, northern Arabian sea

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The present observation illustrates about the incidental sighting of the whale shark, *Rhincodon typus* (Smith, 1828) on 16th January 2018 in the coastal waters of Goa (15°47.086′ N; 073°05.120′ E) at a depth zone of about 74 m onboard the research vessel FORV Sagar Sampada during the cruise No. 370. The sightings were confirmed by visuals in real-time and photographs. This individual was characterized by pale yellow or white rounded to elongated spots on a dark grey background. Satellite-derived oceanographic parameters such as Sea Surface Temperature (SST), Sea Surface Salinity (SSS) and Chlorophyll '*a*', (Chl-*a*) for the location where the animal was recorded, have shown different patterns from rest of the area and thus provided an insight into the preferred environmental conditions and foraging behavior of this species. The sighting location, off the Goa coast, was characterized by high Chlorophyll-*a* (1.2-1.8 mg/m^{-3}), dissolved oxygen (4 ml/l) in the 50 m depth and high concentrations of phytoplankton dominated by green *Noctiluca scintillans*. Present sighting merit the record of *R. typus* with the probability of foraging on the high abundance of phytoplankton in the coastal waters of the Arabian Sea. Therefore, the animal appeared to move along the gradient zones for its seasonal aggregations.

[**Keywords**: Arabian Sea, Coastal waters, Oceanographic parameters, *Rhincodon typus*, Whale Shark]

Introduction

The whale shark *Rhincodon typus* (Smith, 1828) is described by a distinctive pattern of white or yellow spots on the posterior and as the largest fish in the world[1]. It has existed in the world's tropical and warm-temperate waters, in both coastal and deep-sea waters[1-5], particularly as mass aggregation seasonally. It occurs throughout the Indian Ocean[6]. Its occurrence and distribution have been well-known in Indian waters[7]. It is stated from nearly all seafaring states of India including Gujarat[8], Maharashtra[9,10], West Bengal and Goa[11,12], Karnataka[13], Kerala[14], Tamil Nadu[15], and Andhra Pradesh[16]. There are reports of frequent sightings of a whale shark off the Orissa coast[17-20]. Recently, there has been a whale shark sighting in oceanic waters off Andhra Coast[21].

Whale sharks are pelagic in the environment, spending a lot of time in the surface layer, searching for planktonic prey[22,23]. It appears to choose locations with surface water temperatures between 21-25 °C, where cool nutrient-rich upwelling mingles with warm surface waters of salinities between 34-34.5 %[24,25]. These conditions may found to be suitable for the higher production of the planktonic and nektonic organisms[1]. Generally, the distribution and abundance of whale sharks are influenced by oceanographic processes such as upwelling, and fronts, which increase productivity in the local environment[22,26-30]. They also have been reported to be associated with temperate water bodies and other allied environmental factors, which increase productivity in the marine environment favoring localized concentrations of food such as plankton blooms and fish spawning measures[2].

The whale shark has a tendency to swim nearby the surface; especially this behavior makes them vulnerable to surface threats like pelagic fishing and collision with ship seafaring. The major causes of mortality were due to by-catch and incidental capture, except in some areas where direct harvest occurs, e.g. Gujarat, India[11,31]. For the past two decades, several countries like Maldives[32], Philippines[33], Honduras[34], Palau[35], India [36] and few others have banned fishing of whale sharks. Since 28th May 2001, in India whale shark has received uppermost protected status under the Indian Wildlife Protection Act, 1972 Schedule-I[37].

The world conservation union's status this species is listed as an 'intermediate'[38] and however, the IUCN

status of the species is listed as 'Endangered'[39]. In India, whale sharks are protected under Schedule-I of the Indian Wildlife (Protection) Act, 1972[36]. The Convention on the International Trade status of the species is listed as 'endangered' in Appendix-II[40]. Under the United Nations Convention on the Law of the Sea, the whale shark is also included as one of the highly migratory and trans-boundary fish[41]. Whale sharks are protected in many countries, but illegal and incidental capture of this species still continues[42,43]. Babu *et al.*[21] has reported its occurrence in the oceanic waters of the east coast of India. Overall, occurrences of whale sharks seem to be irregular and volatile, which is somewhat a reflection of the absence of information about the animal's habitat and ecosystem.

Materials and Methods

Study area

The surveys were conducted from 11th to 21st January 2018 onboard FORV Sagar Sampada. The cruise was multidisciplinary and hence the cruise tracks were determined by the need for missions; thus the research vessel was used as an observation platform. The survey effort spanned between shallow shelf waters (< 100 m) to deeper outer-shelf/slope waters 09-22° N and 68-78° E. The whale shark was sighted on 16th January 2018 off Goa (15°47.086′ N; 073°05.120′ E) at a depth zone of 74 m (Fig. 1).

Data collection

The observation was carried out from the flying bridge of the FORV Sagar Sampada, with eye height 17 m above the sea level. This enabled the observer used to collect critical ground-truth visual observation of these animals from the research vessel. A single dedicated observer scanned an area of 180° centered on the vessel track using binoculars. The visual observations were carried out during daylight when weather permitted at least 4 km of visibility. A Nikon D750 camera fitted with Nikkor 80-400 mm lens with digital zoom was engaged to capture images of whale shark to assist in confirming species identity. These animals were often difficult to recognize infield, particularly when they appeared at the subsurface for a short time. However, as *R. typus* was observed during surface feeding time and it was identified through its unique color patterns of brownish to dark blue-grey with white round spots on the body stripes[44] that make it very much visible.

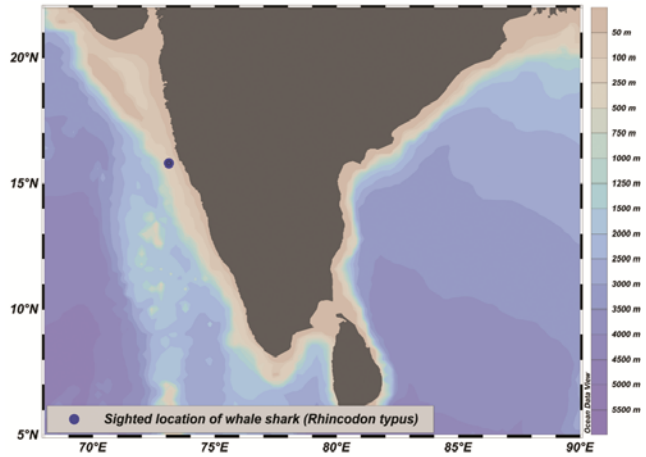

Figure 1 — Sighted location of *Rhincodon typus* on 16th January 2018.

Oceanographic conditions

In order to explain the general oceanographic conditions in whale shark sighting area surroundings (Goa waters), water temperature was recorded by using Conductivity Temperature and Depth (CTD). Remotely sensed sea surface temperature (SST) (°C), acquired from earth system research laboratory (https://esrl.gov/psd/data/gridded/data), and chlorophyll-*a* (CHL) (mg/m^{-3}) from Asia-pacific data-research centre (http://apdrc.soest.hawaii.edu/las/v6/dataset?catitem=13057) and sea surface salinity (SSS) were from Physical Oceanography Distributed Active Archive Center (https://podaac.jpl.nasa.gov/dataset/SMAP_JPL_L3_SSS_CAP_8DAY-RUNNINGMEAN_V4) respectively, for the observation on 16th January 2018.

Results

The whale shark *Rhincodon typus* of an approximate size of 8 m was sighted at surface water on 16th January 2018 at 14:55 hrs in the coastal water

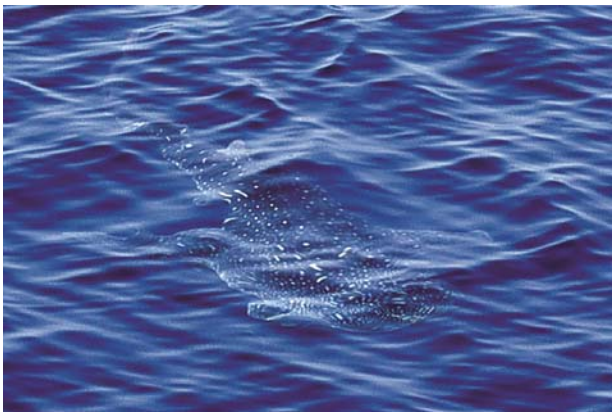

Figure 2 — Whale shark sighted at sea surface level off Goa coastal water, on 16th January 2018.

off Goa (15°47.086′ N; 073°05.120′ E) at a depth zone of 74 m (Fig. 2). Data examined from this cruise (No. 370) included the values of temperature 28.11 °C, salinity 35.8 PSU, fluorescence 0.2 mg/m^{-3} and dissolved oxygen 4.1 ml/l (Fig. 3). The corresponding satellite data derived were as follows: SST 28.11 °C, Chlorophyll-*a* 1.6 mg/m^{-3} and salinity 35.2 PSU (Figs. 4a-c). It was observed that satellite data of temperature and salinity corresponds with the *in-situ* CTD data. The sighted whale shark was easily distinguishable by its colour pattern. Sea surface temperature and primary production were the most important variables in the whale shark sightings. Our observation gives additional confirmation that aggregation of whale sharks in coastal waters happens in response to the presence of planktonic prey at a favorable temperature. Visual observations were recorded when weather permitted at least 4 km of visibility. The sightings suggest that whale sharks occur frequently in the Northern Arabian Sea.

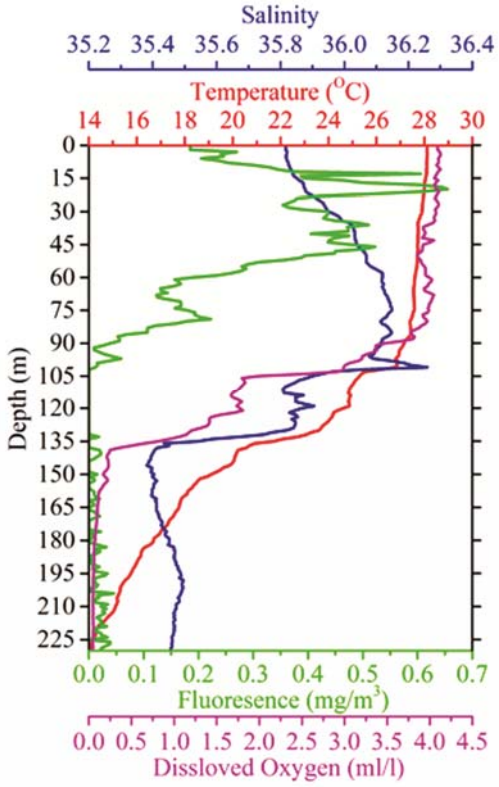

Figure 3 — In-situ profiles of Temperature (°C), Salinity (PSU), Fluorescence (mg/m^{-3}) and Dissolved Oxygen (ml/l) from CTD data at whale shark sighted location.

Discussion

The distribution and abundance of whale sharks are known to be influenced by physical and biological parameters like sea surface temperature, salinity, current and primary productivity[22,45]. The favorable sea surface temperature, salinity, chlorophyll, and phytoplankton bloom were recorded from the sighting area. It was observed that satellite data of temperature and salinity corresponds with the *in-situ* CTD data. The presence of *R. typus* at the Goa coast strongly gives evidence that it is associated with SST values (28.11 °C) and a high concentration of chlorophyll-*a* (1.6 mg/m^{-3}) as observed in the present observation. The observed parameters were found to be suitable for the higher production of the planktonic and nektonic organisms[1]; which are considered to be the main prey for whale sharks. Whale sharks are generally associated with particular physical environments and they move to specific locations where food availability is high[46]. In specific seasons they aggregate to feed in locales with favorable

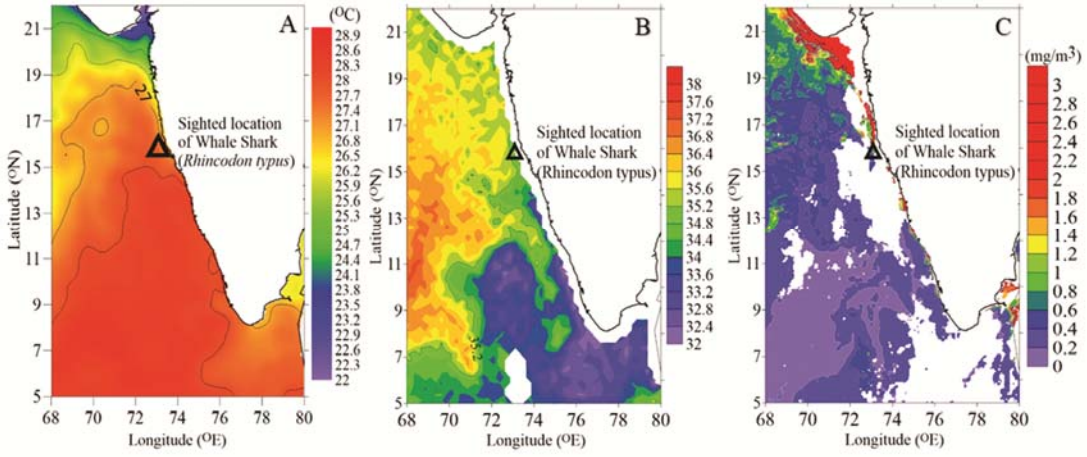

Figure 4 — Effect of the three oceanographic variables; (a) Sea surface temperature; (b) Sea Surface salinity; (c) Weekly composite of Chlorophyll-*a*, concentration of northern Arabian Sea (3rd week January 2018)

oceanographic (i.e. upwelling) or biological (i.e. fish or invertebrate spawning) phenomena[29,47]. Whale sharks have been recorded to feed on recently spawned little tunny eggs in the north-central Gulf of Mexico[45].

In the eastern Arabian sea of India, four important whale shark aggregation sites were identified which include Malvan, Netrani Island, Minicoy, and Kavaratti Island and along the Saurashtra coast of Gujarat[48]. Most frequent sightings were in the Lakshadweep waters followed by the coastal waters of the eastern Arabian Sea. Above 60 % of whale shark sightings were reported in the Arabian Sea during their fishing activities[48]. Our sighting location is also a probable position of its occurrence.

Conclusion

The present observation establishes the fact that whale shark was sighted in a particular location due to the high concentration of phytoplankton and this ascertains that it is an avid phytoplankton feeder. In India, limited information is available on a whale shark and the present survey was an attempt to collect data on the northern Arabian Sea of the whale shark, its habitat, distribution, abundance, and migration patterns to unearth the hotspots of whale shark aggregations in the offshore areas off Goa.

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Conflict of Interest

We declare that we have no conflict of interest.

Author Contributions

Conceptualization: KC NS; Field investigation: KC; Writing – original draft: KC; Writing – review & editing: NS SSC; Project administration & Funding acquisition: MS.

KC – K Chandrasekar; NS – N Saravanane; SSC – Sherine Sonia Cubelio; MS – M Sudhakar

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